Pilot Testing of Oxidation Catalysts for Enhanced Mercury Control by Wet FGD

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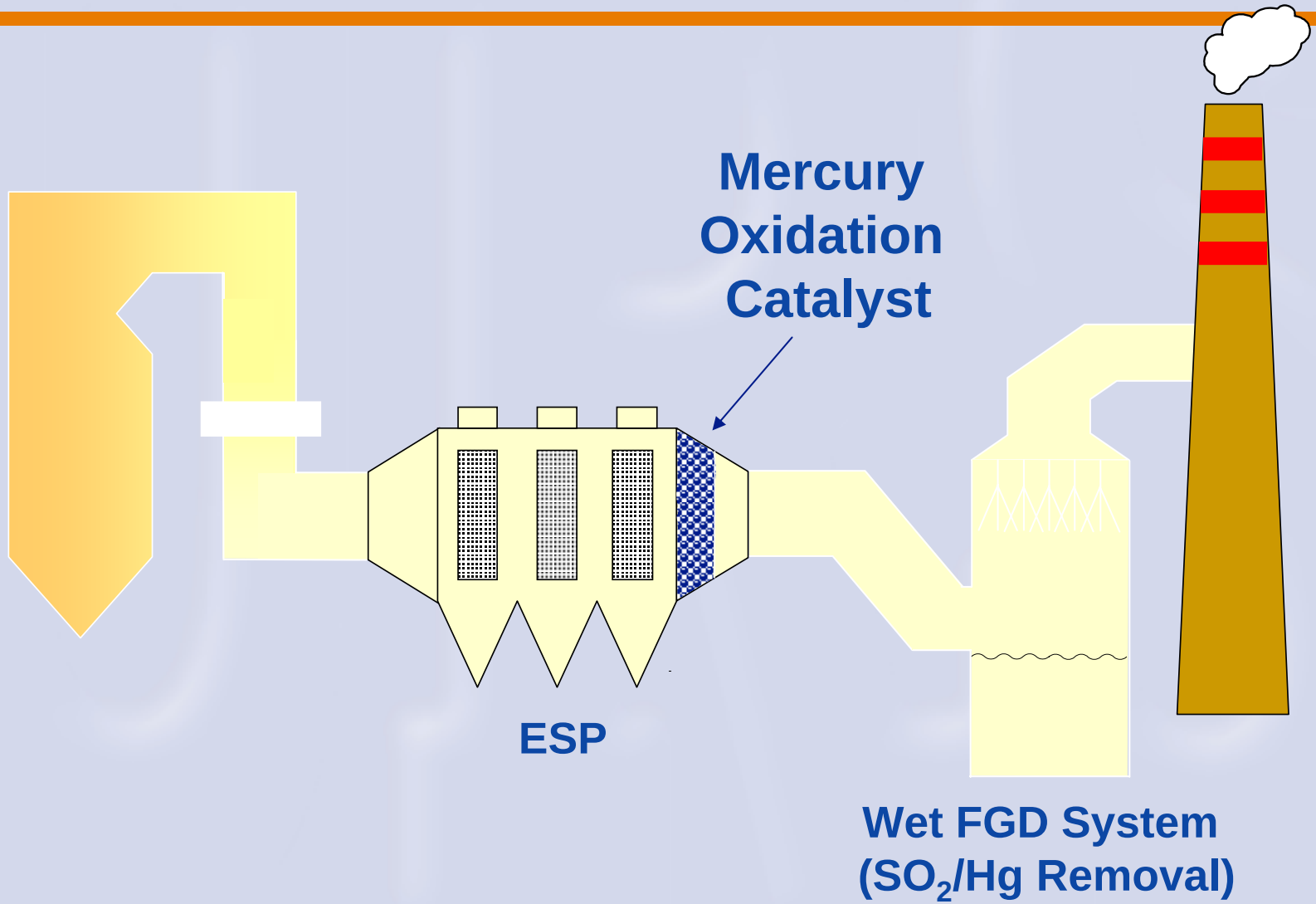
Hg Control Technology Concept

- Catalytic oxidation of Hg^0 in flue gas to increase overall Hg removal across wet FGD systems
- Initial development is focused on PRB and lignite fuels - higher Hg^0 percentages in flue gas
- Catalyst to be installed at ESP outlet

Illustration of Process Concept



Process Development Background

- Initial concept development funded by EPRI (early 1990s)
- Further development in DOE NETL/ EPRI co-funded MegaPRDA Project
  - Lab screening of candidate catalyst materials
  - 6-month sand bed tests with promising catalysts at three coal fired sites
  - Completed in 2001

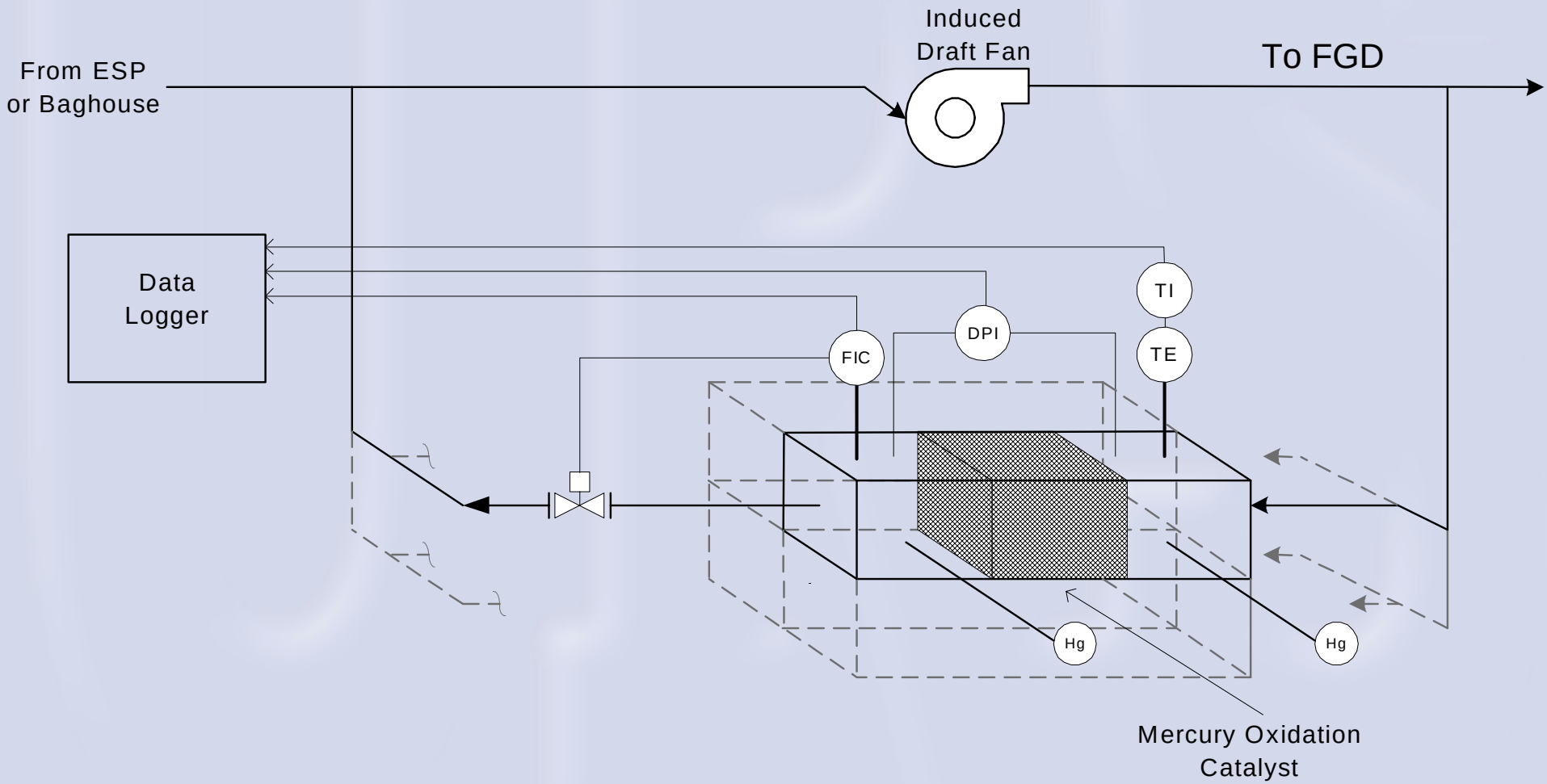
Current Project

- Conduct pilot-scale tests of honeycomb Hg^0 oxidation catalysts at two sites
  - 4 catalysts tested in parallel (~2000 acfm each)
  - 14-months automated operation at each site
  - Monthly activity measurements with Hg SCEM
  - Ontario Hydro relative accuracy tests at beginning, middle, end of test periods
- DOE/NETL, EPRI, utility co-funded
- Host stations include ND lignite (GRE's Coal Creek), PRB fuels (CPS's Spruce)

Catalyst Types Tested

- Metal-based
  - Palladium (Pd #1) - both sites
  - Ti/V from Argillon (SCR) - both sites
  - Gold (Au) - Spruce only
- Carbon-based
  - Experimental activated carbon (C #6) - both sites
- Fly-ash-based
  - Subbituminous coal ash from one particular plant (SBA #5) - CCS only

Pilot Unit Concept



Pilot Testing Status

- First pilot unit started up at Coal Creek in October 02
  - 2 of 4 catalysts installed (Pd #1 and SCR)
  - Delivery of other two catalysts delayed due to developmental nature of their production
- 3rd catalyst (SBA #5) installed December 02
- 4th catalyst (C #6) installed June 03
- Second pilot unit to start up at Spruce Plant later this month

Pilot Unit at Coal Creek Station

Catalyst Dimensions for Pilot Unit

Catalyst	Cells per $in.^2$ (cpsi)	Cross Section (in. x in.)	Length (in.)	Area Velocity (sft/hr)
Pd #1	64	30 x 30	9	49
C #6	80*	36 x 36	9	27
SBA #5	80*	36 x 36	9	27
SCR	46	35.4 x 35.4	19.7	14**

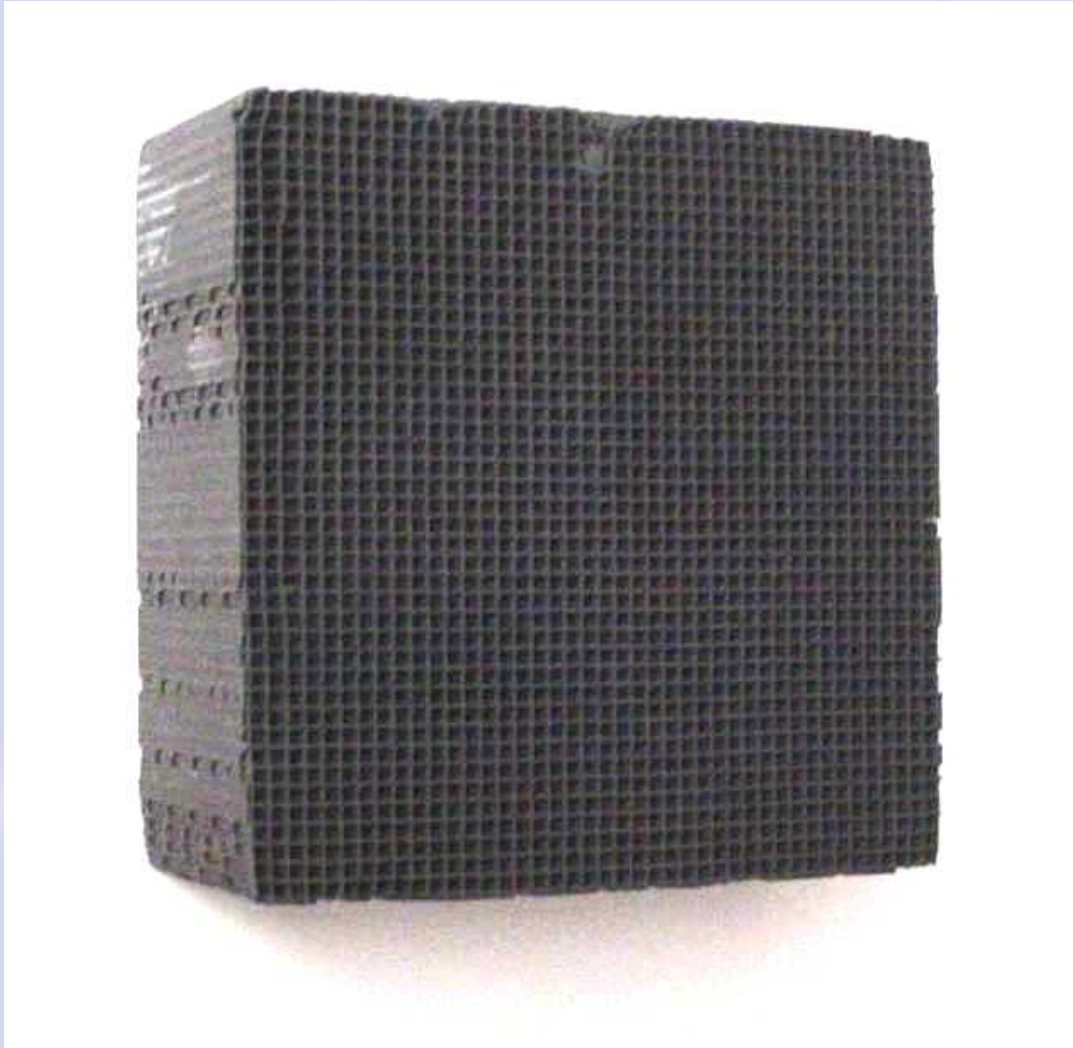
*Die sized for 64 cpsi, cores shrank during drying

**1500 acfm, other catalysts operate at 2000 acfm

Photo of Argillon GmbH SCR Catalyst Module

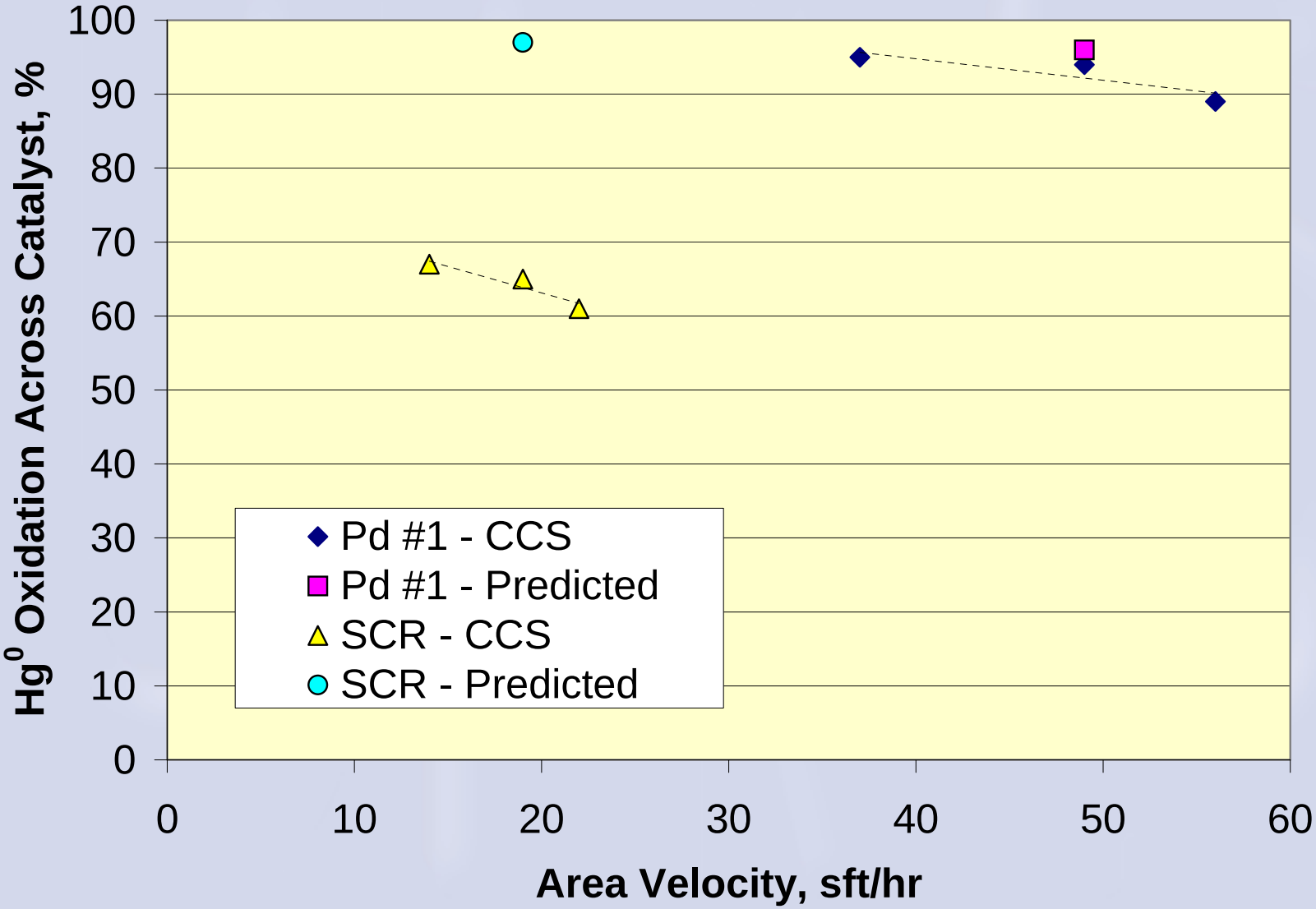
One of Three SBA #5 Catalyst Modules

Close-up of One SBA #5 Block



Initial CCS Pilot Activity Results

Oct. 02 field results vs. lab predictions



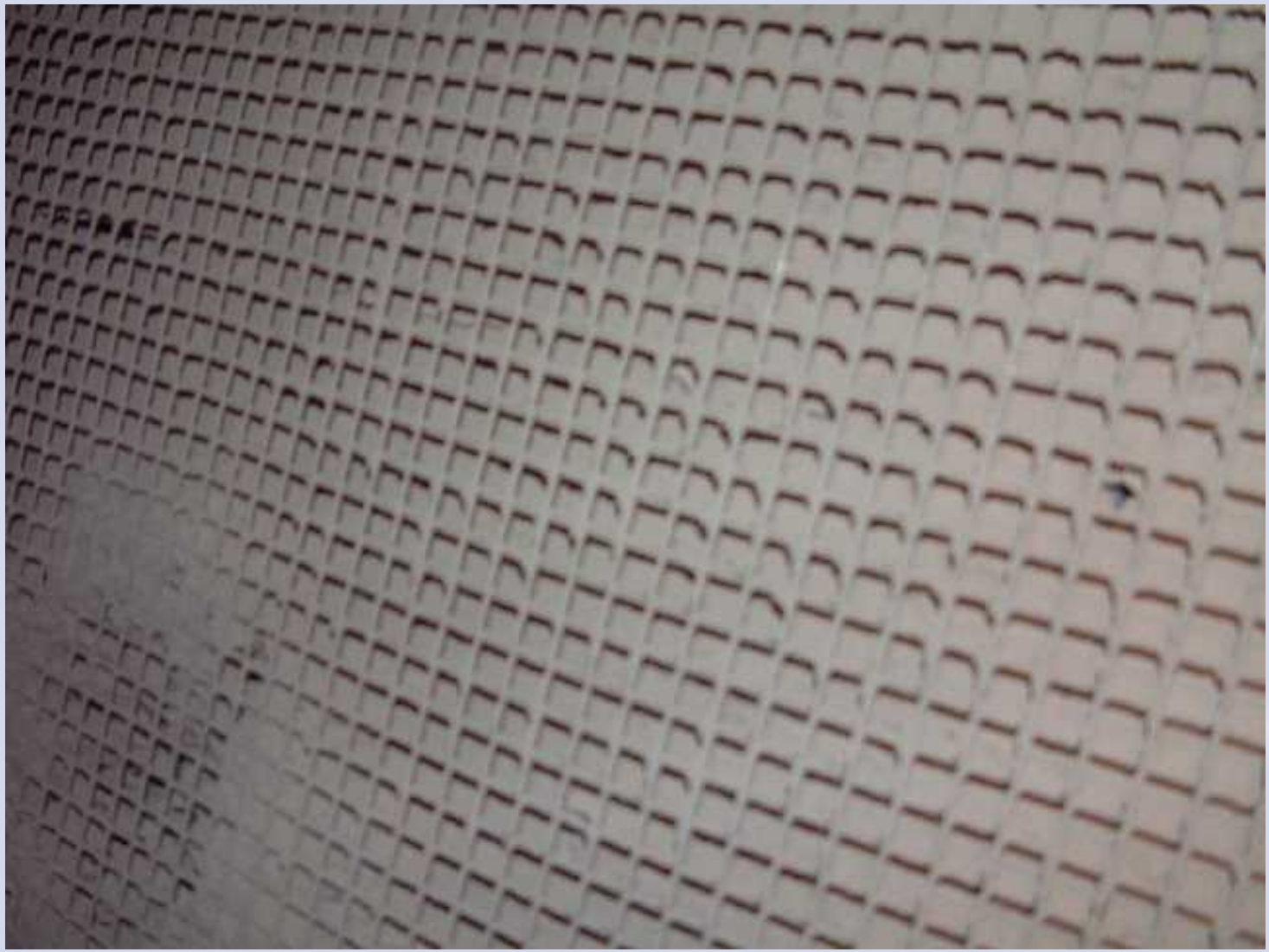
December 02 Results

- Measured activity of Pd #1 and SCR catalysts after ~2 months
  - Both catalysts showed activity loss
- Pressure drop across both catalysts had substantially increased
- Suspected fly ash buildup in horizontal catalysts

January 03 Results

- Measured performance to see if trend for loss of activity continued
  - Activity slightly improved since December
  - Pressure drop indicated continued ash buildup
- Opened catalyst boxes, confirmed fly ash buildup
- Used plant air and vacuum to clean
- Re-measured performance

Surface of Pd #1 Catalyst Prior to Cleaning



Surface of Pd #1 Catalyst after Cleaning

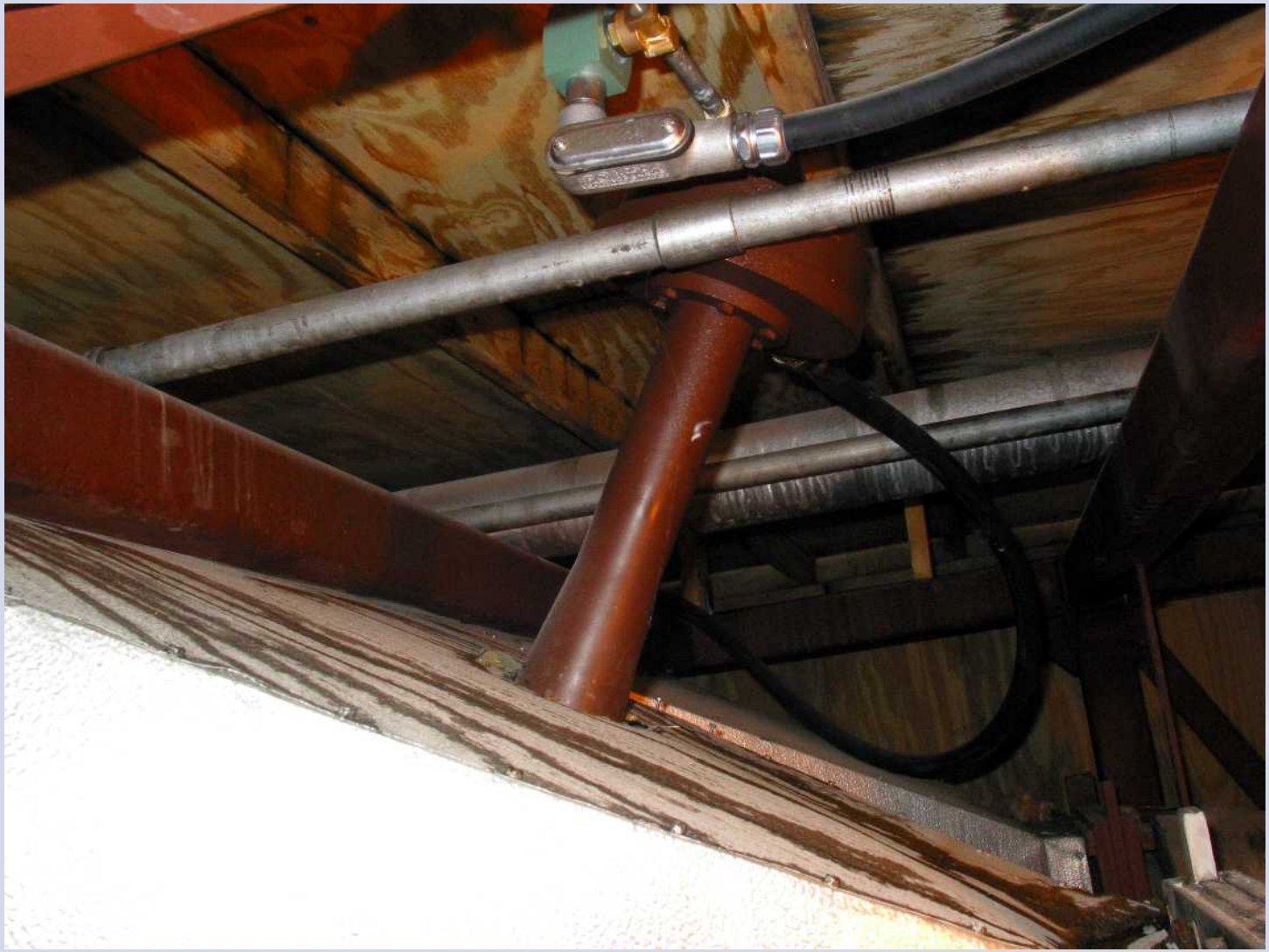
Catalyst Activity Results

	Hg^0 Oxidation across Catalyst (%)			
Catalyst (Flow Rate, acfm)	**October**	**December**	**January**	**January (after cleaning)**
Pd #1 (2000)	93	53	58	91
SCR (1500)	67	28	37	61
SBA #5 (2000)	na*	na*	59	75

Efforts to Resolve Ash Buildup

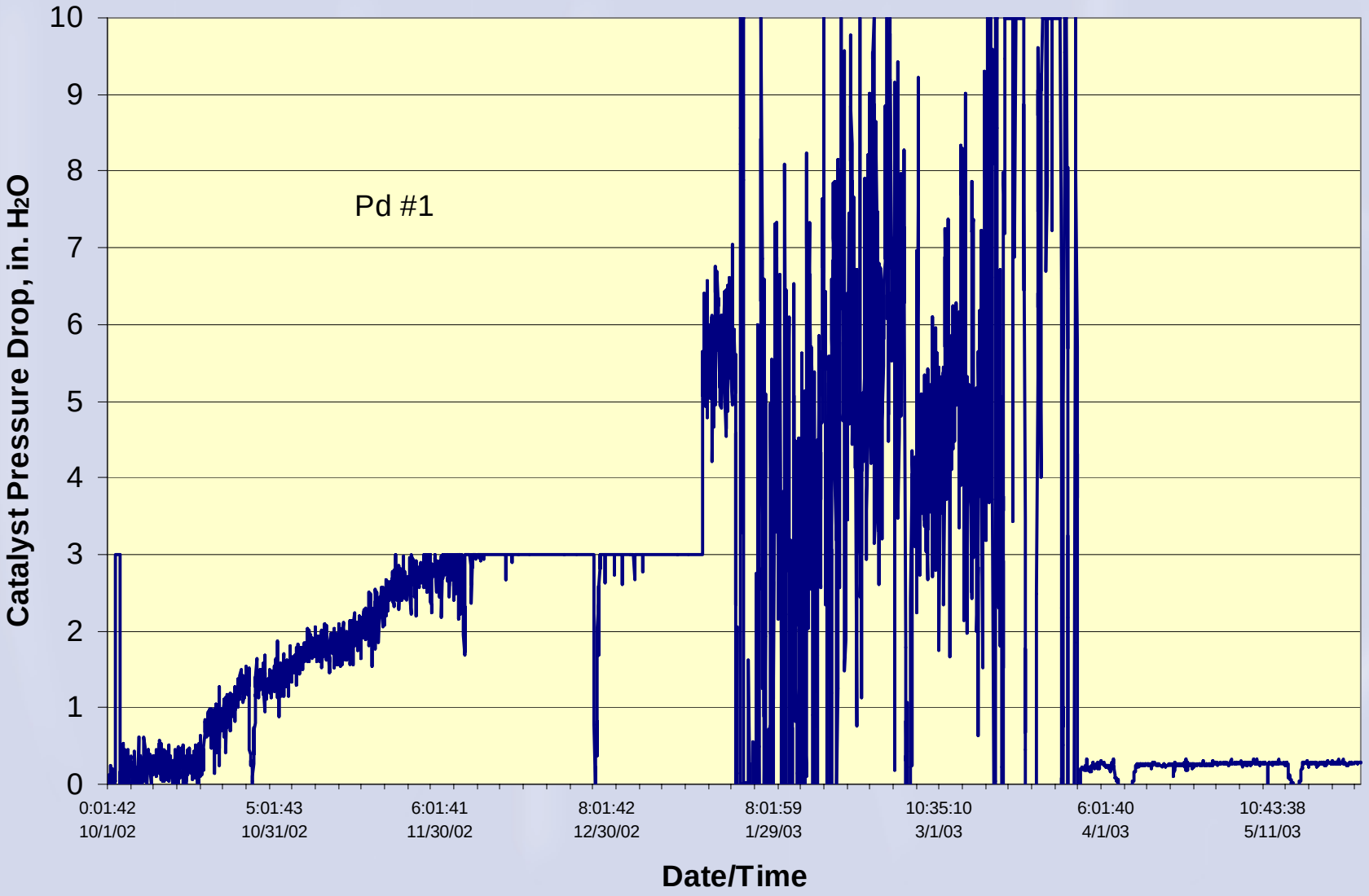
- Identified sonic horns as a likely mechanism to limit fly ash buildup
  - Commonly used to clean SCR catalysts
- Tested horn (Analytec 17”) on Pd #1 catalyst chamber
  - Installed perpendicular to chamber inlet transition duct
  - Appeared effective in 2 mos. operation
  - Installed on other chambers June 03

Sonic Horn Installation on Pilot Unit

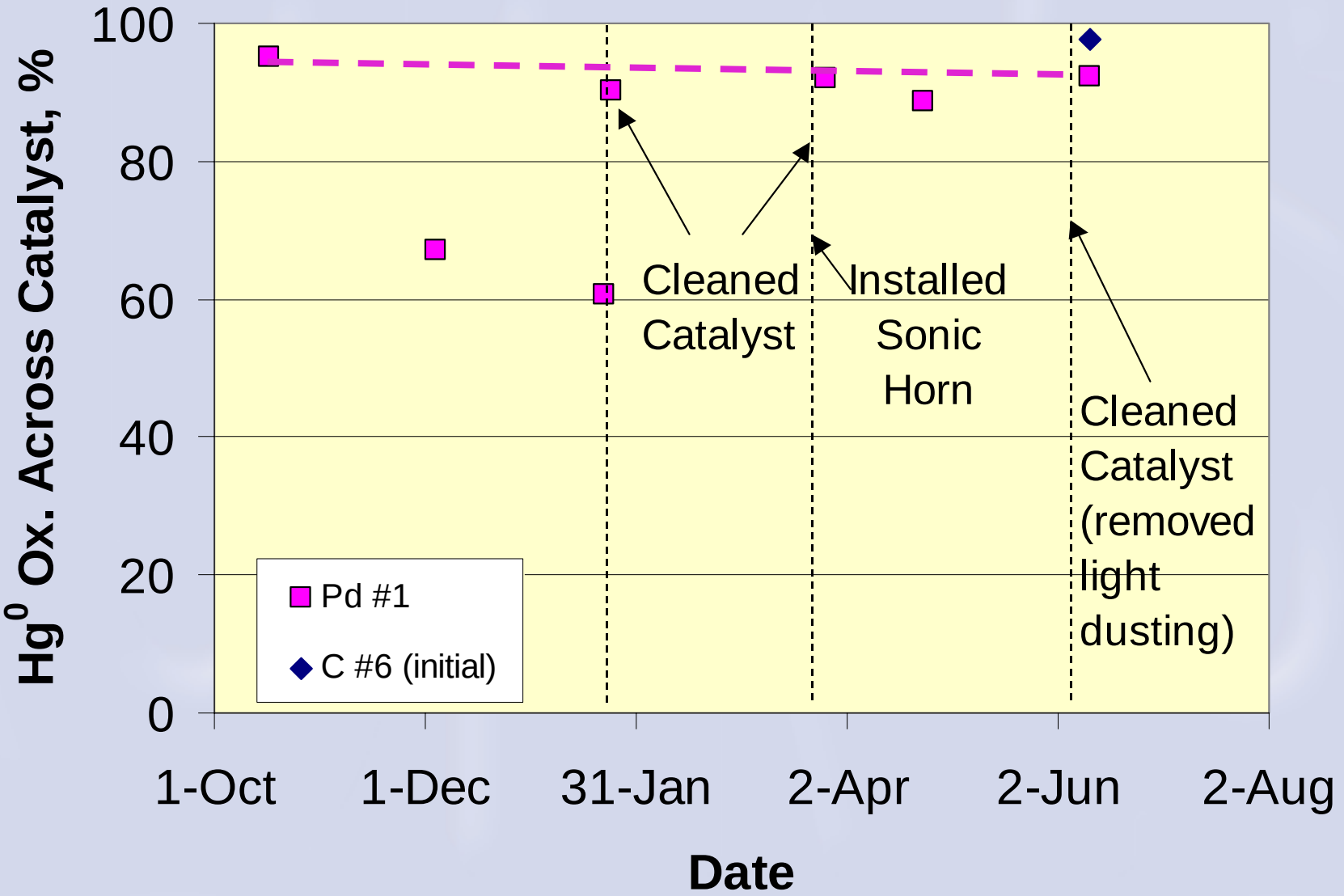


Sonic Horn Location

Catalyst Pressure Drop thru 5/27
(shows sonic horn effect on Pd #1 catalyst)



Catalyst Activity Trends over First 8 Months at Coal Creek



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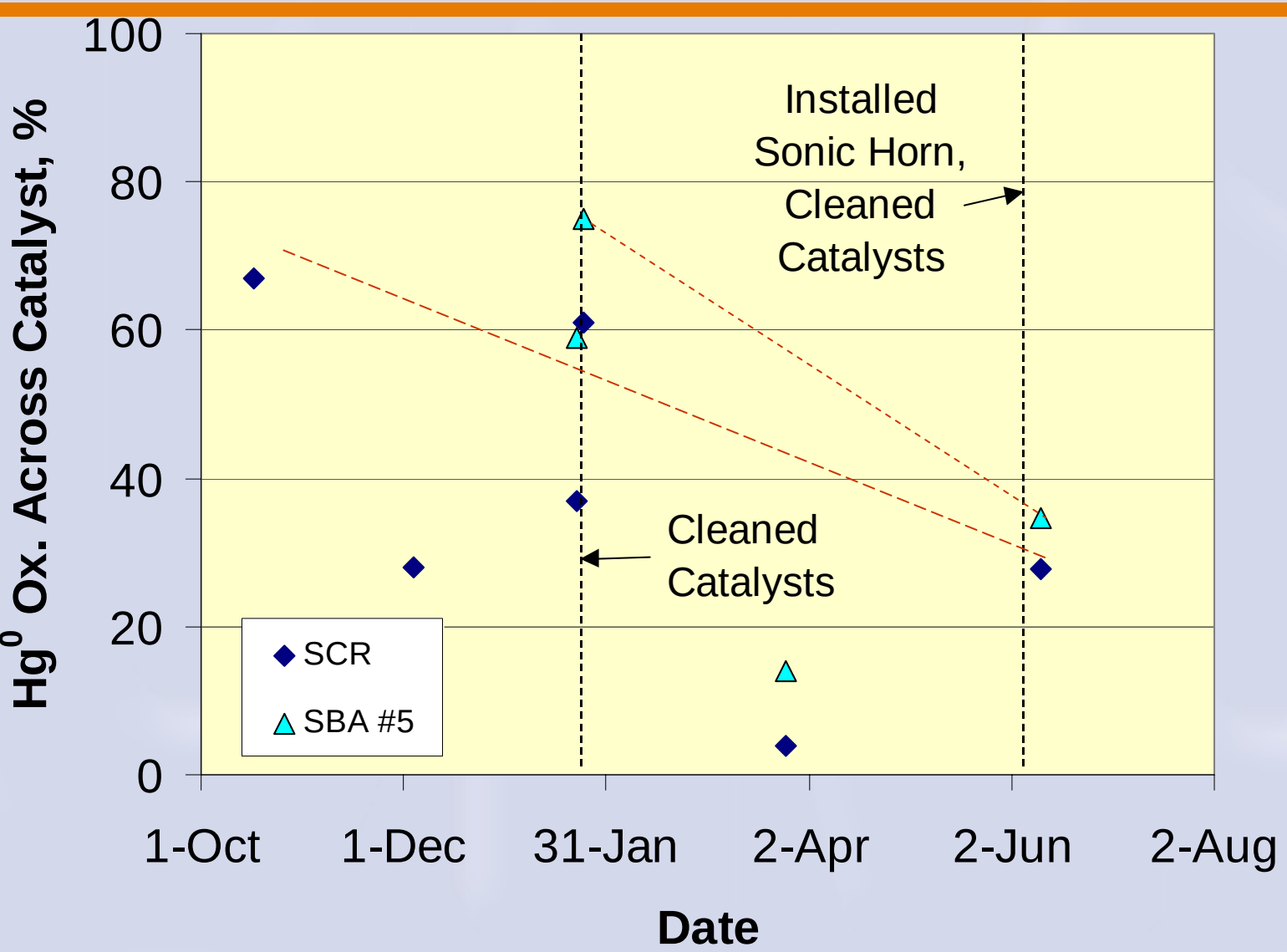
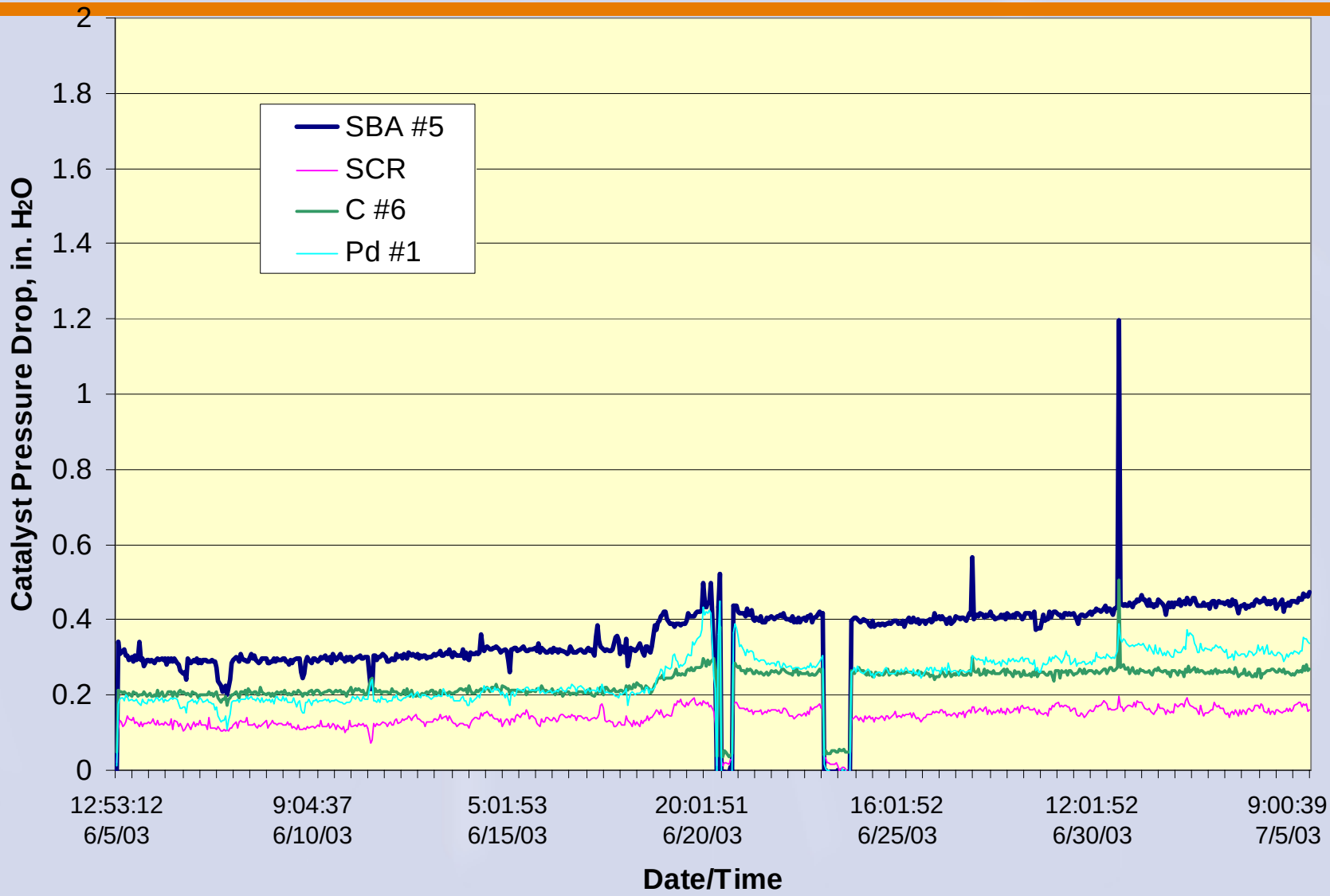


Catalyst Pressure Drop since 6/5
(sonic horns in all 4 compartments)



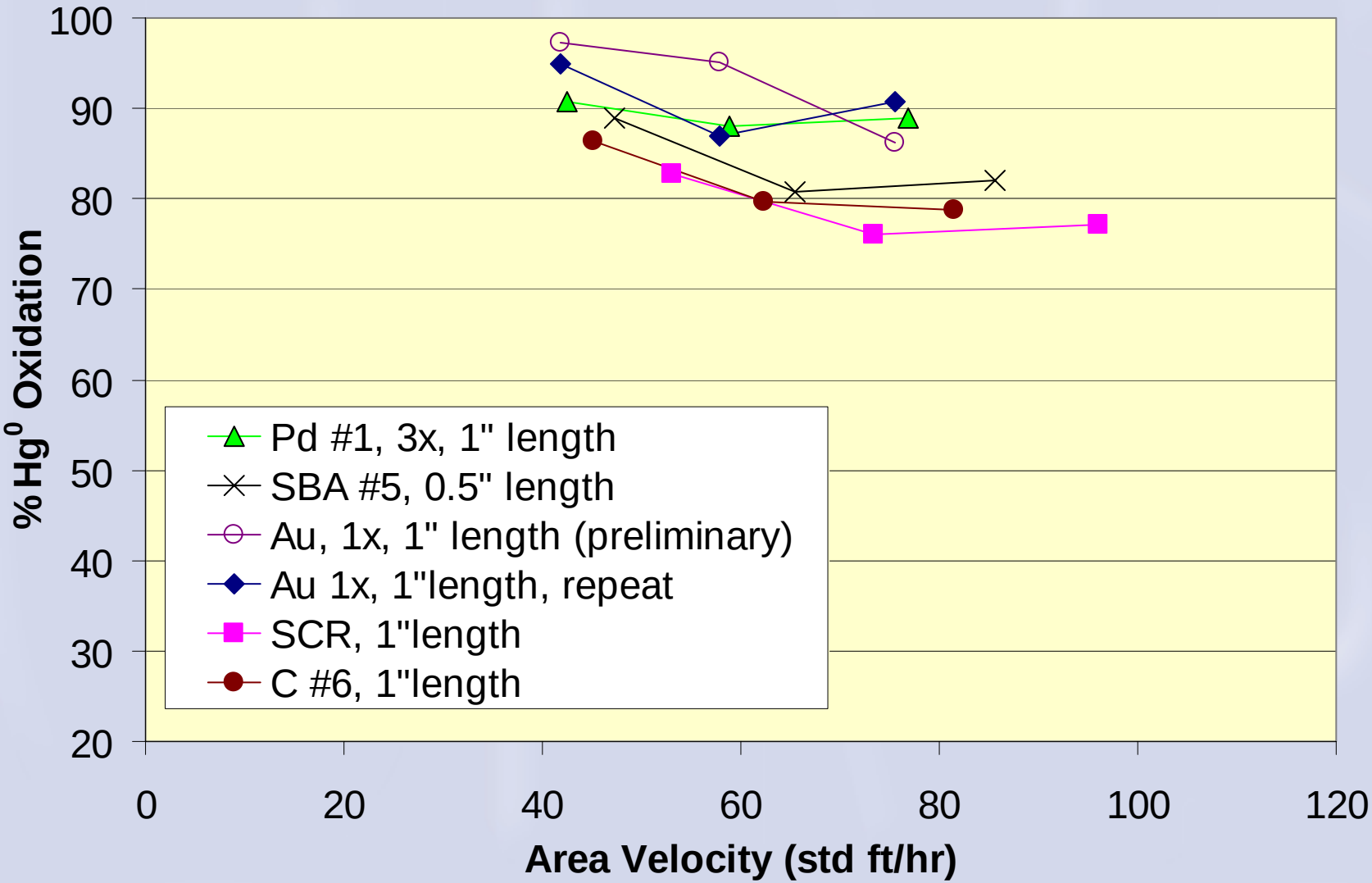
Flue Gas Characterization Results - Other Species

- Ontario Hydro results show good agreement with EPRI Hg SCEM
- Controlled Condensation results showed no oxidation of SO_2 across catalysts
  - Catalyst inlet and outlet SO_3 ~0.1 ppmv
- Little or no oxidation of NO across catalysts
  - Inlet and outlet NO, total NO_X values agree within 10 ppm (precision level of technique)
- M26a showed no change in HCl (~1 ppm) or HF (~6 ppm) across catalysts

Lab Testing

- 1 to 2 l/min testing of catalyst cores in simulated flue gas (SO_2, HCl, NO_X, etc.)
- Tested TVA's patented gold catalyst in honeycomb form, varied gold loadings
  - Activity compares favorably with Pd #1
  - May be effective at lower wash coat loading on alumina than Pd #1
  - Selected as 4th catalyst for Spruce (SBA #5 fly ash not a likely commercial catalyst source)
- Tested other catalyst materials at Spruce conditions

Results of Spruce Laboratory Simulations



Catalyst Selection for Spruce Pilot

- Pd #1 and C #6 selected based on high activity at CCS
- Au selected based on positive lab results
  - Need field results to compare activity, life to Pd #1
- Will test SCR catalyst in spite of activity loss at CCS
  - Loss could be site specific based on previous PRDA sand bed results with other catalysts
- All catalysts re-ordered at current pitch (Au the same as Pd)

Current Schedule

- Continue SCEM measurement trips to Coal Creek through early 04
  - Conduct 3rd set of Ontario Hydro SCEM relative accuracy tests ~March 04
- Start up 2nd pilot unit at Spruce later in August
  - Initial shake-down operation w/o catalysts
  - Expect Pd and Au catalysts by end of August
  - SCR and C #6 catalysts late September

Proposed Follow-on Project

- Proposal submitted in NETL large-scale Hg control testing solicitation
- Would use existing pilot units to test Hg oxidation catalysts at 2 new sites starting Spring 04
  - TXU's Monticello Station (Tx lignite/PRB blend)
  - Duke Energy's Marshall Station (low S Eastern bit.)
- Proposed effort would integrate new wet FGD pilot unit downstream of oxidation catalysts
  - 2000 acfm flow rate to match catalysts
  - Would test LSFO vs. Mg-lime chemistries

Summary

- Pilot tests results verify previous sand-bed results for the ability to catalytically oxidize Hg^0 in flue gases
  - Honeycomb catalysts have achieved over 90% oxidation of Hg^0 in ND lignite flue gas
- On-line cleaning (sonic horns) needed to prevent fly ash buildup in horizontal gas flow catalysts
- Continued testing will establish catalyst life for two coal types